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A Technical Review of Grid Connected Solar Photovoltaic System with MPPT Techniques

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Abstract: The Maximum Power Point Tracking (MPPT) is a technique used in power electronic circuits to extract maximum energy from the Photovoltaic (PV) Systems. In the recent decades, photovoltaic power generation has become more important due to its many benefits such as it needs a few maintenance with environmental advantage of being fossil fuel free. However, there are two major barriers for the use of PV systems, low energy conversion efficiency and high initial cost. To improve the energy efficiency, it is important to work PV system always at its maximum power point. So far, many researches has conducted and many papers were published and suggested different methods for extracting maximum power point.
Keyword: Maximum Power Point Tracking, Perturb and Observe, Incremental Conductance, Photovoltaic System.

I. INTRODUCTION

The usage of modern efficient photovoltaic solar cells (PVSCs) has featured as an mastermind alternative of energy conservation, renewable power and demand-side management. Due to their initial high cost, PVSCs have not yet been an exactly a tempting alternative for electrical users who are able to purchase less expensive electrical energy from the utility grid. However, they have been used widely for air conditioning in remote areas, water pumping and in isolated or remote areas where utility power is not available or is highly expensive to transport. Although PVSC prices have decreased considerably during the last years due to new developments in the film technology and manufacturing process [1]. The harnessing of solar energy using PV modules comes with its own problems that arise from the change in insulation conditions. Those changes in insulation conditions strongly influence the efficiency and output power of the PV modules. A great deal of research has been accomplished to improve the efficiency of the photovoltaic system. Several methods to track the maximum power point of a PV module have been suggested to solve the problem of efficiency and products using these methods have been made and now commercially available for consumers [2-3].

As the market is now flooded with species of these MPPT that are intentional to improve the efficiency of PV modules under different isolation conditions, it is not known how many of these can actually provide on their promise under a diverse field conditions. This research then looks at how a different kinds of converter affects the output power of the module and also achieve if the MPPT that are said to be highly efficient and do track the true maximum power point under the different conditions.

A maximum power point tracker is used for obtaining the maximum power from the solar PV module and conversion to the load. A non-isolated DC-DC converter (step up/ step down) offers the purpose of converting maximum power to the load. A DC-DC converter acts as an interface between the load and the module. By varying the ratio of duty cycle the impedance of load as it appears by the source is varied and matched at the peak power point with the source so as to the conversion of the maximum power [4-5]. Therefore maximum power point tracker methods are required to maintain the PV array's working at its MPP. Many MPPT methods have been suggested in the literature ; example are the Perturb and Observe (P&O) methods, Incremental Conductance (IC) methods and Constant Voltage Methods.

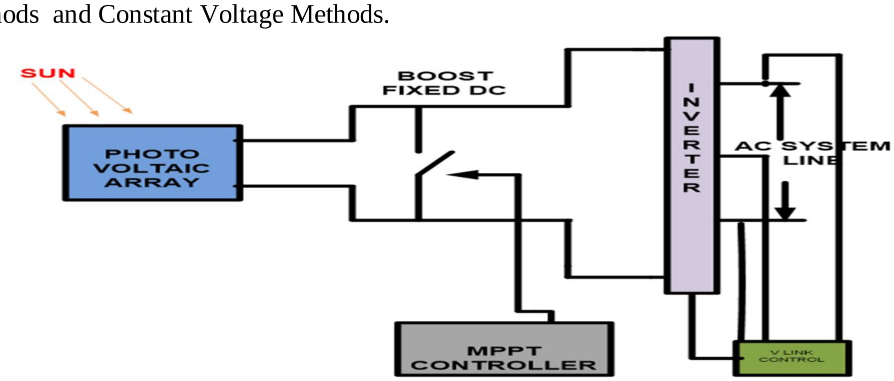

Fig.1. PV module and dc/ dc converter with MPPT

II. PHOTOVOLTAIC CELL

Photovoltaic generators are neither fixed current sources nor voltage sources but can be approximated as current generators with dependent voltage sources. During dark hours, the solar cell is not an active device. It produces neither a current nor a voltage. A solar panel cell essentially is a pn semiconductor junction. When exposed to the light, a current is generated (DC current).The generated current changes linearly with the solar irradiance. Figure 2 shows the equivalent electrical circuit of an ideal solar cell.

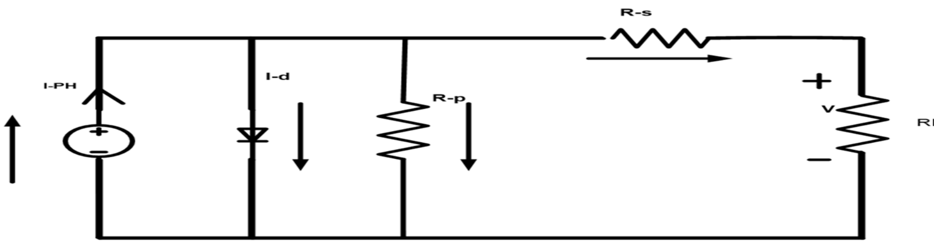

Fig.2. Equivalent circuit of a solar cell

The I-V characteristics of the solar cell circuit can be sets by the following equations [14]. The current through diode is given by:

$I_D = I_O$ [exp (q (V + I RS)/KT)) – 1] (1)

While, the solar cell output current: $I = I_L – I_D$ – I sh (2)

$I = I_L – I_O$ [exp (q(V + I RS)/KT)) – 1] – (V + IRS)/ Rsh (3)

Where,

I: Solar cell current (A)

I_L: Light generated current (A)

I_O: Diode saturation current (A)

q: Electron charge (1.6×10-19 C)

K: Boltzman constant (1.38×10-23 J/K) T : Cell temperature in Kelvin (K)

V: solar cell output voltage (V)

Rs: Solar cell series resistance (Ω)

Rsh: Solar cell shunt resistance (Ω)

III. MPPT CONTROL ALGORITHM

The nature of MPPT is mostly influenced by three factors of environmental changes. The quality of each cells of solar panel are chiefly influenced by – a)Insolation b)Temperature c) Partial criteria of shading. Their impacts on various factors are shown under.

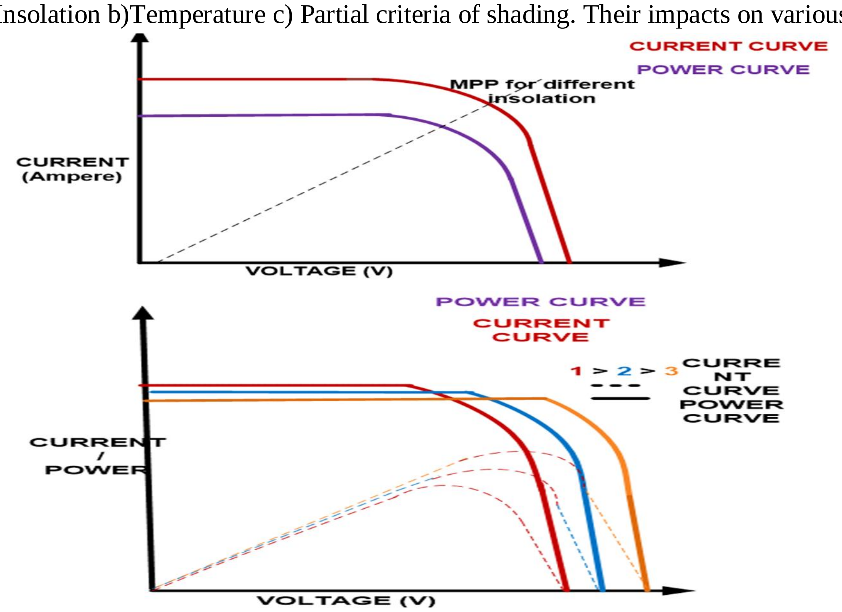

Fig 3: Solar I–V and P–V curve (a) with different temperature insolation and (b) MPP for different Insolation

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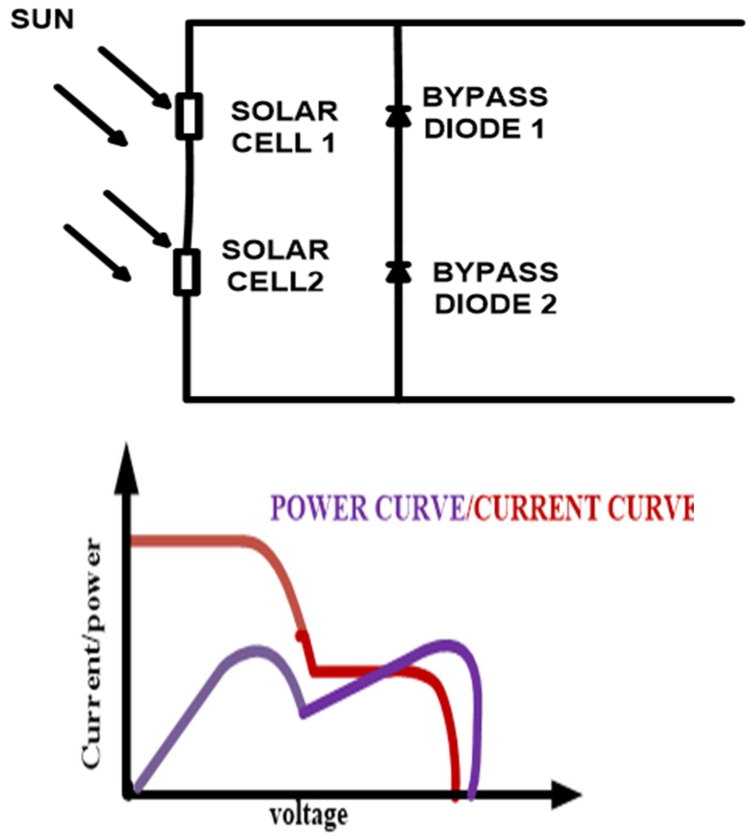

Fig 4(a) Operation of solar P-V under partial shading condition, (b) P–V graph under same partial shading criteria

From fig 4(a): Connected solar cell with its terminal V: V1 andV2, overall power P and total voltage V. Thus it is seen that all these time variant and environmental dependent factors shows a major contribution in the adjustments of the operation point or highest or maximum power point tracker [MPP] throughout the whole day. Its behavior i.e. high power point tracker is there to make a shift in the continuously varying operating point [P max] here PV module delivers highest power.

1) Perturb and Observe (P&O)
2) Incremental Conductance (InCond)
3) Constant Voltage Method.

IV. PERTURB & OBSERVE [P&O] ALGORITHM

Solar cell power module changes continuously, in case of power increment, the perturbation will be continued in (same) as previous direction.

TABLE 1: FOR PERTURB & OBSERVATION METHOD

Sign of dv	Sign of dp	Direction of next step.
Positive	Positive	+C
Negative	Negative	+C
Negative	Positive	-C
Positive	Negative	-C

The power will then at next step will decrease as soon as maximum power is attained, and after this perturbation will reverse. The algorithm starts oscillating around its highest point as soon as the steady value is reached. Size of perturbation is kept very small, thus power variation small. Even then this algorithm is important in mega service as it is simple. The algorithm can be understood from study of flow chart, which is shown above.

V. INCREMENTAL CONDUCTANCE (IC)

Incremental Conductance Algorithm: IC method overtakes the demerits of Perturb & Observe method in tracking out the highest power under fast fluctuating condition of an environment criterion. This described method determines if the MPPT has found its Maximum value by using MPPT & also will stop perturbing the point of operation. If these criteria are failed then, the direction of the MPPT operating point should be perturbed and is calculated by using relationship b/n dl/dv & –I/V.

This relationship is found from existing fact that dp/dv has negative value when MPPT is at the right side of a MPP & positive at the left of the MPP. This algorithm finds when the MPPT has obtained the MPP, where as P&O oscillates or varies nearby or around MPP. This simply shows an advantage over P&O. Also, InC can track rapidly rising & decreasing irradiance criteria's with higher accuracy than perturb & observe method [4].

The demerits of InC algorithm are that it is more manifolds when this method is compared to P&O. The given algorithm is shown below by which an idea of its following procedure can easily obtain as shown in fig:

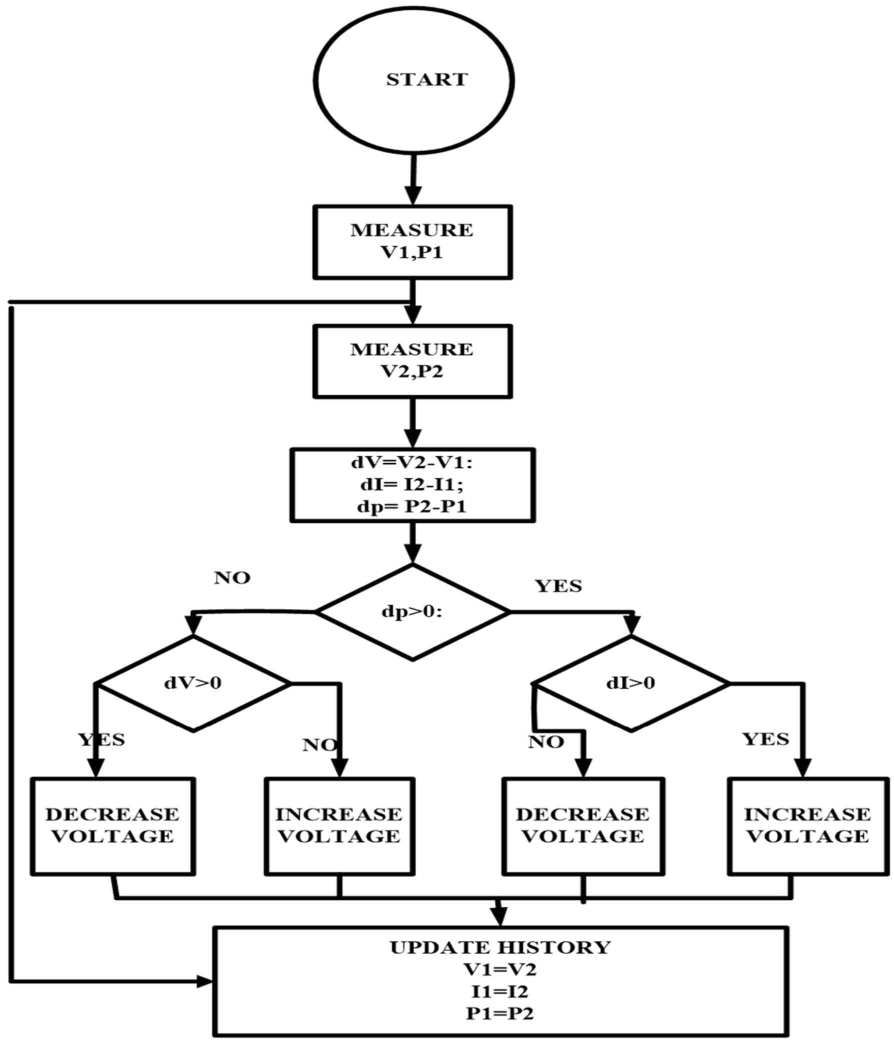

Fig 5 : Flow chart of Perturbation and observation

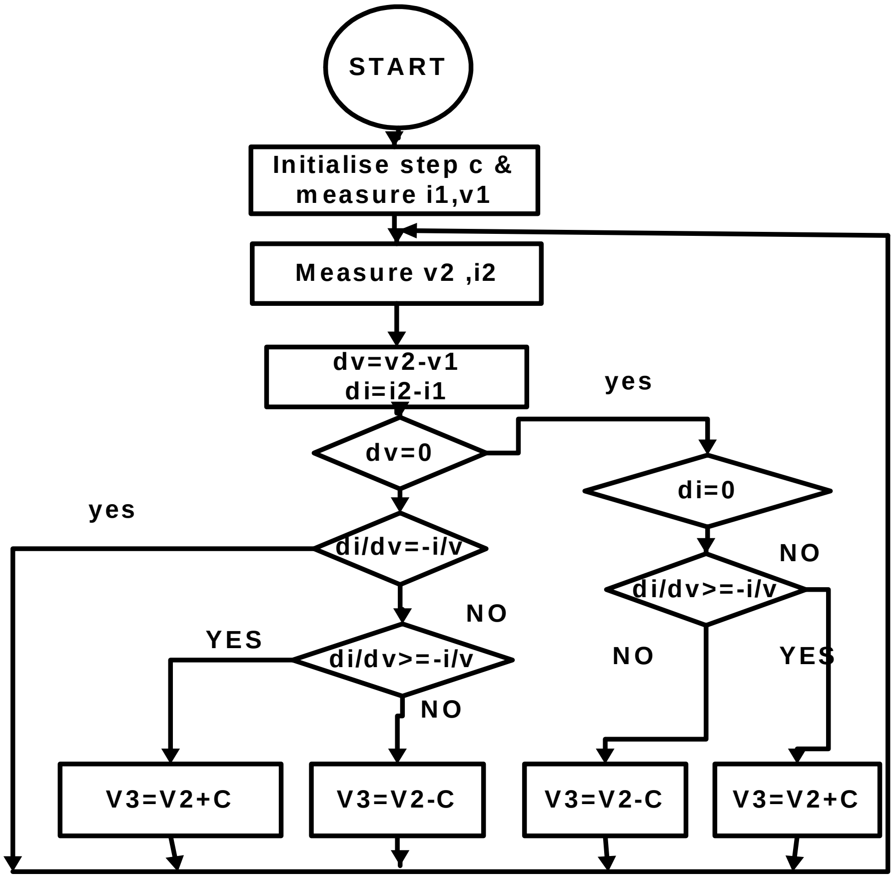

Fig: 6: Incremental conductance flow chart

The InC depends on a particular condition that the given slope of a PV array power graph is zero when at its MPP, positive at its left of a MPP, & is negative on its right as given:

$dp/dv \geq 0$	left of MPP	(4)
$dp/dv \leq 0$	right of MPP	(5)
$dp/dv = 0$	at MPP	(6)
Since,		
$dp/dv = d(iv)/dv$	$= I + V di/dv$	(7)
$di/dv \geq -i/v$	left of MPP	(8)
$di/dv \leq -i/v$	right of MPP	(9)
$di/dv = 0$	at MPP	(10)

A. *Constant I Method*

Constant I has similarity in the phenomena as that of a constant V method. In case of constant V method the reaction of PV array functions is based on constant V at the equivalent time as in case of the constant current method where it depends upon constant current. The highest power point is obtained b/n 78% & 92% of its value.

B. *Hill Climbing Method*

Hill climbing method and P &O method are two different methods with same fundamental principle. P&O involves perturbation in terminal voltage to perform MPPT whereas the Hill climbing method involves perturbation in duty ratio (δ). The methodology is explained in the Table and flow chart given below.

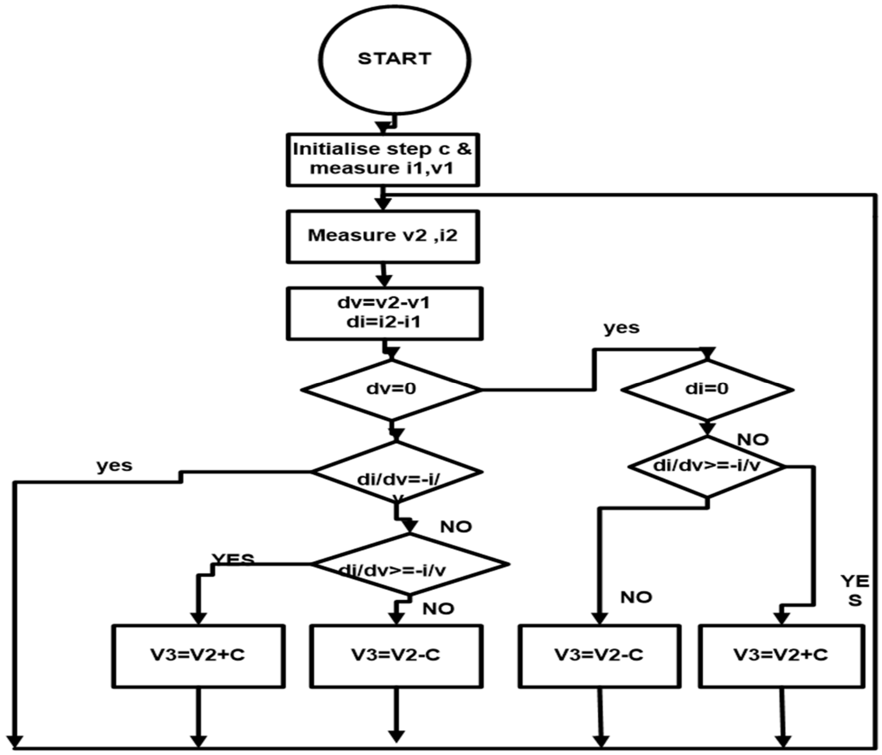

Fig 7: Flow chart of Hill climbing method

TABLE 2: HILL CLIMBING METHOD

Perturbation in terminal voltage	Change in power	Next Perturbation
Positive	Positive	Positive (increment in duty ratio)
Positive	Negative	Negative (Decrement in duty ratio)
Negative	Positive	Negative (Decrement in duty ratio)
Negative	Negative	Positive (increment in duty ratio)

VI. CONCLUSION

The MPPT method presented in this paper is able to improve the dynamic and steady state performance of the PV system simultaneously. It is observed that the system completes the maximum power point tracking successfully despite of fluctuations. When the external environment changes suddenly the system can track the maximum power point quickly.

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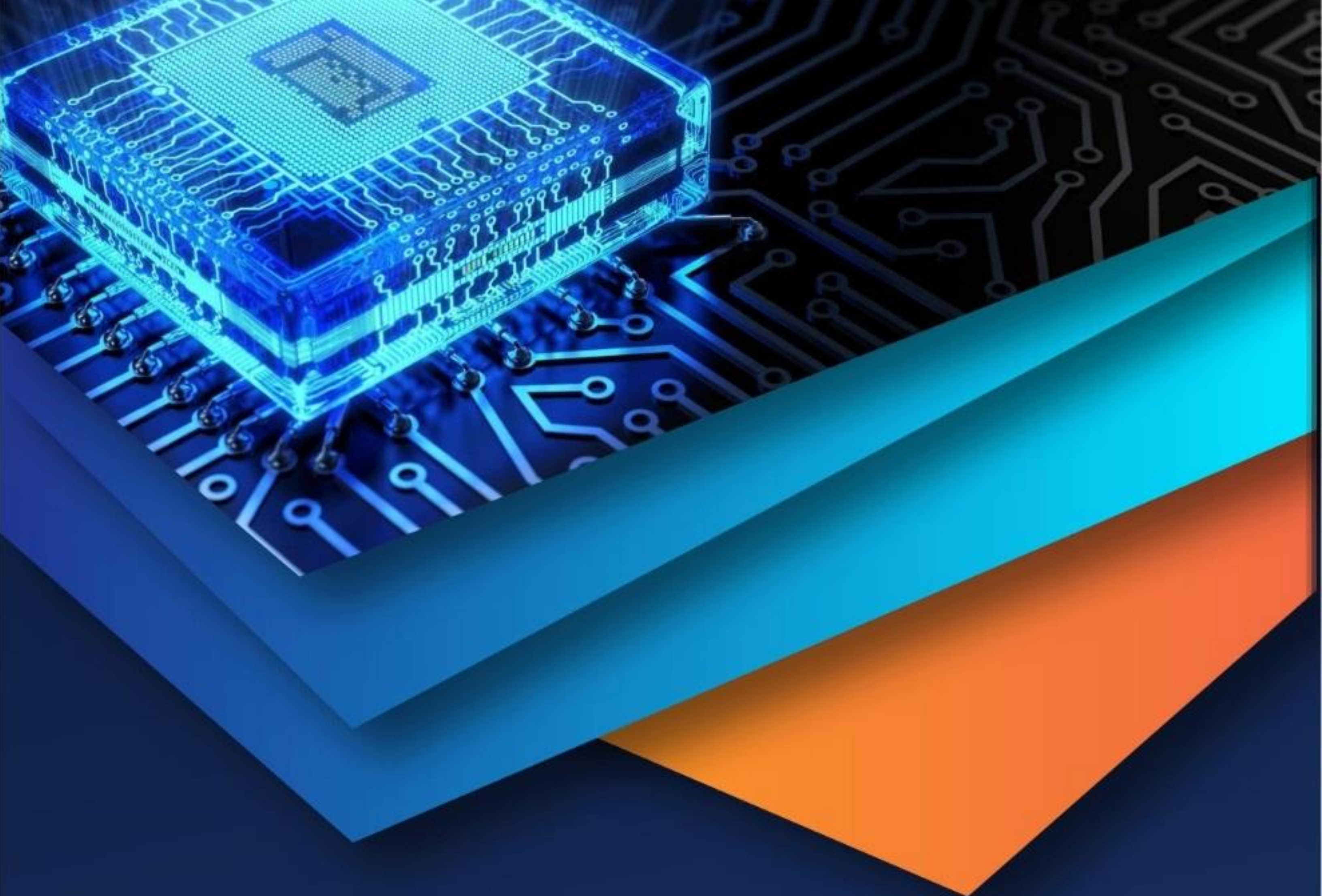

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